Supplementary Material for

A Shallow Water Case of Ordovician Marine Red Beds (South China): Evidence from Sedimentary Structures and Response to the Kwangsian Orogeny

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Table S1. Geochemical analysis procedures of this study

Category	Experimental methods	Standards	References	Analysis procedures
Major elements	X-ray fluorescence spectrometry (XRF)	GB/T 14506.28-2010	Zhang et al. (2004)	The instrument used was an Axios X-ray fluorescence spectrometer, and the test accuracy was 0.2%. The main steps included placing approximately 0.7 g of the sample in a 25 mL porcelain crucible, adding 5.2 g of anhydrous lithium tetraborate, 0.4 g of lithium fluoride and 0.3 g of ammonium nitrate, and stirring evenly. Samples were then transferred into platinum crucibles, where 1 mL of lithium bromide solution was added. The crucibles were then placed on a hot plate for drying and melted at 1150 °C for 15 minutes on the automated burner. Finally, they were poured into the proper mould for testing.
Trace elements	Inductively coupled plasma mass spectrometer (ICP-MS)	GB/T 14506.30-2010	Xu et al. (2010)	The instrument used was an iCAP-Qc Inductively Coupled Plasma Mass Spectrometer (ICP–MS), and the accuracy is better than 98%. The main steps included placing 200 mesh samples in an oven at 105 °C for drying for 12 hours, weighing 40 mg of homogenized samples and placing them in a Teflon acid digestion chamber, and slowly adding 1 ml of high purity HNO3 and 1 ml of high purity HF successively. The Teflon digestion chambers were securely placed in a steel sleeve and then transferred to an oven heated to 190 °C. The samples were then heated for more than 48 hours, after which they were left to cool and then left uncovered on a 140 °C hot plate. Next, 1 ml of HNO3 was added, the samples were dried again, and the process was repeated three times. Then, 1 ml of high purity HNO3 and 1 ml of MQ water were added, and the Teflon acid digestion chambers were placed into the steel sleeve and returned to the 190 °C oven for more than 12 hours after being secured. The solution was transferred into a polyethylene bottle and diluted with 2% HNO3 (for a mass of 80 g) for the ICP–MS test.

Table S2. Elements in sedimentary geochemistry of the Sanbaidong section (major elements %; trace elements 10^{-6})

Sample	CaO	SiO_2	Al_2O_3	P_2O_5	TFe	FeO	Ba	Cu	Ce	Th	Sr	LOI	Paleosalinity
HHY-1	51.63	3.89	1.08	0.23	0.64	0.40	24.7	8.46	17.4	3.18	24.5	41.16	124.0955
HHY-2	47.92	6.89	2.66	0.05	1.42	0.59	47.5	3.93	28.0	5.24	24.0	38.82	123.663
HHY-3	43.31	11.86	4.26	0.34	1.95	0.35	72.6	8.86	32.2	5.18	20.8	35.42	122.7061
HHY-4	48.42	7.01	2.33	0.10	1.09	0.46	45.5	2.97	23.9	4.87	24.5	38.81	124.7395
HHY-5	42.91	11.96	4.32	0.06	1.99	0.94	81.1	4.29	24.7	6.08	23.5	35.04	124.5869
HHY-6	48.34	7.33	2.13	0.10	1.11	0.25	74.4	3.59	21.3	3.80	26.3	39.20	124.0904
DW-1	34.64	21.44	6.90	0.07	2.97	0.57	156.7	2.64	43.1	7.67	21.9	29.53	124.3749
DW-2	31.87	23.63	8.10	0.07	3.48	0.53	186.3	2.93	46.5	8.40	20.0	27.81	123.9513
DW-3	34.94	20.18	7.52	0.08	2.78	0.47	197.4	3.84	42.2	7.20	22.1	29.86	123.1763
DW-4	30.91	23.72	8.90	0.08	3.86	0.47	235.2	3.92	46.5	8.32	20.2	27.21	123.6215
DW-5	21.19	34.89	11.97	0.08	5.46	0.62	300.3	4.32	58.2	10.90	17.0	20.15	123.4304
DW-6	20.09	37.42	11.84	0.12	5.08	0.87	331.8	17.8	59.4	11.50	16.8	19.26	123.4937
DW-7	20.89	37.65	11.23	0.09	4.32	0.80	286.9	10.9	56.3	11.10	17.5	19.77	123.7443
DW-8	38.99	16.35	5.68	0.07	2.31	0.40	159.2	9.27	37.6	6.47	26.5	32.51	124.442
DW-10	25.29	30.86	10.58	0.10	5.07	0.70	316.4	6.96	68.4	11.42	22.0	22.29	124.034
DW-11	24.28	34.32	10.38	0.08	4.09	0.70	304.1	7.99	68.9	12.20	20.9	21.38	124.1049
DW-12	20.93	37.81	11.28	0.14	4.47	0.80	334.4	11.4	73.3	13.13	19.3	18.98	124.1458
DW-13	24.41	34.92	10.04	0.07	3.79	0.90	380.6	15.6	62.5	12.52	22.0	21.05	124.2947
DW-14	22.29	35.98	10.86	0.14	4.59	0.90	355.2	20.6	75.1	13.12	22.0	19.78	124.1027
DW-15	25.29	30.86	10.58	0.10	5.07	0.70	316.4	6.96	68.4	11.42	22.0	22.29	124.034
DW-16	24.28	34.32	10.38	0.08	4.09	0.70	304.1	7.99	68.9	12.20	20.9	21.38	124.1049
DW-17	20.93	37.81	11.28	0.14	4.47	0.80	334.4	11.4	73.3	13.13	19.3	18.98	124.1458
DW-18	24.41	34.92	10.04	0.07	3.79	0.90	380.6	15.6	62.5	12.52	22.0	21.05	124.2947
DW-19	22.29	35.98	10.86	0.14	4.59	0.90	355.2	20.6	75.1	13.12	22.0	19.78	124.1027
DW-20	24.28	35.38	9.84	0.07	3.29	0.80	305.1	10.7	73.3	13.72	25.0	21.13	124.2682
DW-21	21.58	36.38	11.87	0.14	4.59	1.00	369.1	10.6	75.1	13.92	20.0	19.52	124.1541
DW-22	21.24	36.98	11.44	0.14	4.89	0.80	349.2	17.2	77.0	13.92	20.0	19.14	123.8398
DW-23	18.38	38.57	12.66	0.14	6.04	1.00	467.6	28.1	80.7	13.72	19.0	17.38	123.8962
DW-24	20.13	38.66	11.66	0.14	4.64	0.90	391.5	33.1	81.4	14.52	22.0	18.27	124.0185
DW-25	19.08	39.17	12.38	0.07	5.04	0.70	393.6	16.3	84.5	15.42	19.0	17.77	124.0944
DW-26	24.28	31.48	10.88	0.07	4.89	0.70	344.2	17.4	72.1	12.15	20.0	21.81	124.0385
DW-27	17.06	40.99	13.05	0.14	5.89	1.00	410.1	43.8	87.5	15.52	17.0	16.27	124.0395
DW-28	18.79	36.19	13.29	0.14	6.49	0.90	417.2	26.8	89.4	14.42	18.0	17.98	123.858
GNT-1	45.79	12.09	3.03	0.07	1.19	0.60	159.2	14.8	29.5	5.46	33.0	36.37	124.7601
GNT-2	48.44	9.56	1.97	0.03	0.66	0.42	97.8	3.68	23.6	3.53	31.8	38.12	125.2212
GNT-3	45.01	13.12	2.66	0.03	0.87	0.53	314.4	3.64	29.4	4.72	31.6	36.22	125.1758
GNT-4	33.76	25.72	6.09	0.04	2.09	0.72	995.1	5.62	51.2	10.35	25.4	28.33	124.9002
GNT-5	43.12	15.32	3.12	0.03	1.03	0.33	252.4	4.75	31.5	5.72	28.4	34.99	125.0623
GNT-6	46.32	12.42	2.37	0.03	0.72	0.23	184.6	4.06	27.3	4.23	30.4	36.71	125.204
GNT-7	36.22	23.22	5.19	0.04	1.72	0.63	106.0	5.38	43.2	8.05	25.4	29.99	125.1929
GNT-8	46.32	11.62	2.07	0.03	0.72	0.23	366.7	4.37	23.6	3.99	33.4	37.37	125.0706
GNT-9	41.12	17.32	3.88	0.04	1.32	0.43	283.5	5.62	35.4	6.41	27.4	33.48	125.028
GNT-10	47.44	10.52	2.12	0.03	0.72	0.13	124.2	5.52	22.9	3.97	29.4	37.52	125.4038
GNT-11	44.42	14.62	2.8	0.03	0.92	0.23	184.6	7.52	28.5	5.32	31.6	35.32	125.4752
GNT-12	31.52	26.22	7.67	0.03	3.12	0.73	247.3	5.12	54.9	10.54	25.4	27.22	124.0883
GNT-13	31.82	27.42	6.96	0.04	2.32	0.93	141.0	15.3	47.2	9.06	26.4	27.15	124.2383
GNT-14	42.22	15.92	3.7	0.03	1.32	0.53	605.1	3.92	33.2	5.77	29.4	34.18	124.9362
GNT-15	45.72	12.02	3.03	0.03	1.12	0.63	159.2	14.8	29.5	5.46	33.0	36.37	124.7601

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3	2	8		0	3	9		6	1		7			**73**	7			6	7	9		2	2		2	1		**10**		6		5	2	1		8	8		1	7	
DW-5	22.6	33.0	11.8	0.1	5.6	0.6		12.	68.	12.1	19			**DW-1**	44.7	11.4		0.0	1.5	0.2		7.5	38.		32	35.9		**GNT-1**	36.4	20.0		0.0	2.5	0.4		7.3	54.		27	30.7	
4	2	2	8	0	7	7	505	6	8	3	5	20.5	123.5149	**74**	7	9	3.77	5	3	9	186	2	1	5.26	3	8	125.0507	**11**	8	6	6.14	5	2	2	357	1	4	8.33	7	2	125.0164
DW-5	25.5	30.5	10.7	0.1		0.5		12.	62.	11.1	21			**DW-1**	47.0			0.0	1.2	0.2			35.		32	37.9		**GNT-1**		12.2		0.0	1.5	0.2		7.4	37.		32	35.8	
5	8	5	4	0	4.8	9	450	3	9	2	5	22.6	123.5758	**75**	2	8.58	2.84	5	5	2	135	5.5	4	4.15	1	1	125.0828	**12**	44.3	6	3.54	5	2	3	234	9	4	5.09	2	2	125.1194
DW-5	26.6	29.8		0.0	4.4	0.6		15.	60.	10.8	23	23.2		**DW-1**	43.9	11.4		0.0	1.7	0.3		5.6	42.		31	36.6		**GNT-1**	45.1	11.0		0.0	0.9	0.3			39.		33		
6	5	9	9.93	9	5	7	500	6	7	6	0	3	123.5614	**76**	4	5	3.88	5	3	3	197	2	3	5.69	0	3	125.0568	**13**	8	8	3.24	4	8	4	199	13	2	4.74	1	36.6	125.4869
DW-5	27.4	28.5		0.0	4.3	0.6		14.	56.	10.2	23	23.9		**DW-1**	46.0	10.5		0.0	1.2	0.2		7.2	35.		34	36.8		**GNT-1**	35.7	21.1		0.0	2.5	0.5		6.7	57.		27	30.6	
7	8	8	9.55	9	4	3	468	6	7	4	5	4	123.6527	**77**	7	3	3.04	5	8	9	160	1	0	4.71	3	7	125.2201	**14**	7	6	6.35	4	1	8	505	6	7	8.88	1	9	125.0983
DW-5	26.1	30.4	10.3	0.0	4.4	0.5		14.	68.	12.7	24	22.9		**DW-1**	38.3	18.8		0.0	2.2	0.4		5.6	47.		27	31.5		**GNT-1**	44.6	11.2		0.0	1.6	0.4		4.9	43.		32	36.1	
8	8	2	8	8	8	4	389	8	1	1	6	4	123.1507	**78**	7	1	5.49	5	4	8	483	7	0	7.89	2	1	124.8122	**15**	5	8	3.56	5	4	0	248	8	3	5.11	1	5	125.3242
DW-5	23.3	31.9		0.0	5.5	0.5		13.	67.	12.5	20			**DW-1**	46.6			0.0	1.2	0.3		5.5	33.		32	37.5		**GNT-1**	41.9	15.0		0.0	1.8	0.5		5.0	56.		30	33.3	
9	3	5	11.3	9	9	5	346	5	5	0	9	21.1	123.4839	**79**	7	9.23	2.94	4	6	4	146	2	0	4.24	2	1	125.2206	**16**	3	8	4.6	5	7	0	302	8	6	6.94	5	3	125.4304
DW-6	28.1	27.5		0.0	4.5	0.5		11.	57.	10.2	23	24.4		**DW-1**	42.9			0.0	1.7	0.3		5.7	39.		29	35.3		**GNT-1**	35.1	21.8		0.0	2.7	0.5		5.6	65.		27	29.6	
0	9	3	9.81	8	1	7	283	1	2	5	4	7	123.3616	**80**	9	12.4	4.08	4	2	9	211	2	5	5.66	9	8	125.1847	**17**	8	4	6.56	5	3	6	767	3	6	9.83	5	8	125.2727
DW-6	30.7	25.3		0.0	3.8	0.4		9.7	49.		24	26.0		**DW-1**		20.7		0.0	2.3	0.4		5.8	49.		27	30.3		**GNT-1**	43.9			0.0		0.5		4.5	46.		30	36.2	
1	9	2	8.29	9	6	7	244	2	9	9.21	9	6	123.4169	**81**	36.6	2	5.99	5	2	7	306	5	1	8.46	3	9	125.0363	**18**	4	11.4	3.84	4	1.7	3	290	6	4	5.11	9	3	125.4321
DW-6	26.0		10.2	0.1	4.5	0.5		8.2	61.	11.3	23	22.6		**DW-1**	47.1			0.0	1.1	0.5			30.		31	38.0		**GNT-1**	45.7	10.1		0.0	1.3	0.7		9.4	33.		33	36.9	
2	6	30.8	7	0	5	5	820	7	1	2	6	8	123.5813	**82**	4	8.53	2.69	5	2	3	148	27	7	4.03	6	5	125.1215	**19**	2	4	3.24	5	8	2	230	1	9	4.59	0	2	125.6098
DW-6	27.7	28.6		0.0	4.4	0.4		6.6	56.	10.0	22	23.9		**DW-1**	46.7			0.0		0.5		24.	32.		33	37.3		**GNT-1**	44.4	11.1		0.0	1.6	0.8			42.		32		
3	1	6	9.9	9	8	7	512	5	2	9	8	4	123.7717	**83**	8	9.73	2.85	4	1.2	3	159	1	7	4.26	0	1	125.3324	**20**	2	4	3.81	4	6	1	241	9.2	4	5.13	0	36.2	125.6203
DW-6	26.8	28.0		0.0	4.8	0.5		6.4	60.	10.6	22			**GNT-**				0.0	1.2	0.6		31.	30.		31	37.4		**GNT-1**	46.5			0.0	1.3	0.4		7.2	33.		33	37.7	
4	9	8	10.6	9	4	5	413	9	4	0	0	23.5	123.6815	**1**	46.9	9.24	2.89	4	4	3	152	1	4	3.97	6	6	125.3529	**21**	5	9.14	2.97	4	2	4	185	9	8	4.23	3	1	125.5843
DW-6	31.5	23.8		0.0	3.8	0.4		6.8	50.		24	26.7		**GNT-**	44.8	10.5		0.0	1.0	0.8			37.		33	36.8		**GNT-1**	36.1			0.0	2.7	0.6		5.3	58.		27	30.2	
5	1	5	8.57	8	6	6	282	5	9	8.99	2	5	123.7883	**2**	9	7	3.48	5	6	0	542	8.2	7	5.02	2	4	125.2533	**22**	2	20.7	6.28	4	3	6	400	2	7	8.73	4	1	125.467
DW-6	30.3	25.4		0.1	4.0	0.5		6.5	51.		23	25.9		**GNT-**	47.9			0.0	0.7	0.4		25.	32.		34	38.2		**GNT-1**	36.7			0.0	2.4	0.5		6.8	58.		28	30.8	
6	2	5	9.13	0	2	8	262	1	1	9.57	5	6	123.9051	**3**	7	8.51	2.52	4	9	8	172	3	7	3.97	2	3	125.1426	**23**	2	20.1	5.9	4	8	9	389	2	4	8.54	1	5	125.2976
DW-6	31.7	24.1		0.1	3.9	0.6		6.8	49.		25	26.7		**GNT-**	46.1			0.0	1.2	0.5		62.	33.		31	37.2		**GNT-1**	43.5	12.3		0.0		0.3		5.9	43.		31	35.5	
7	4	2	8.43	0	1	6	240	2	1	8.60	1	6	123.6709	**4**	9	9.71	3.26	4	8	6	213	2	2	4.47	2	4	125.6031	**24**	9	7	3.97	5	1.7	1	269	9	1	5.62	9	9	125.421
DW-6	30.5	24.6	9.11	0.1	4.1	0.5	255	8.9	53.	9.29	24	26.4	123.894	**GNT-**	46.5	9.74	2.86	0.0	1.3	0.5	137	3.3	31.	4.31	32	37.3	125.1847	**GNT-1**	45.4	10.6	3.36	0.0	1.5	0.2	221	6.2	37.	4.80	34	36.8	125.5029

8	6	5		0	6	6		2	0		2	9		**5**	5			4	3	8		8	8		0	1		**25**	8	2		4	1	9		5	4		1	2	
DW-6	28.0	27.8		0.1	4.4	0.6		7.5	57.	10.5	23	24.2		**GNT-**	47.7			0.0	0.9	0.3		33.	31.		32	38.0		**GNT-1**	40.7	15.2		0.0	2.0	0.4		7.4	43.		29	33.6	
			9.67				271									8.88	2.72				123			4.15					4.75				310			6.12			
9	7	8		1	2	2		6	0	9	2	1	123.8829	**6**	3			4	8	9		9	4		5	9	125.281	**26**	4	7		5	8	1		2	2		5	7	125.4764
DW-7	37.3	18.8		0.0	2.5	0.4		12.	38.		27	30.4		**GNT-**	41.9	15.0		0.0	1.1	0.5		86.	42.		30	34.3		**GNT-1**	43.4	12.6		0.0	1.8	0.4		4.3	39.		30	35.2	
			6.16				189			7.15							4.4				691			6.50					4.12				345			5.36			
0	1	8		9	3	8		8	3		9	4	124.0932	**7**	9	6		5	4	7		1	7		4	3	125.2544	**27**	7	8		5	5	2		4	6		3	9	125.338
DW-7	33.9	21.0		0.0	3.7	0.6		12.	46.		27	28.4		**GNT-**	48.2			0.0	0.6	0.3		11	32.		33	38.2		**GNT-1**	40.3	15.8		0.0	2.1	0.5		4.8	46.		30	33.3	
			7.84				224			8.04						8.46	2.54				108			3.98					4.81				515			6.83			
1	9	4		7	6	1		4	2		3	7	124.0396	**8**	1			4	3	6		5	3		1	7	125.3424	**28**	3	4		6	4	3		6	9		2	8	125.6408
DW-7				0.0	3.4	0.6			53.		26	27.0		**GNT-**	33.8	23.0		0.0	3.1	0.7	166	68.	62.	10.2	25	28.6		**GNT-1**	44.1	11.3		0.0	1.7	0.9		9.7	39.		33		
	32.1	24	8.44				239	22		8.67						8.63	7.01												3.8				274			5.21			
2				9	2	8			5		6	1	123.6444	**9**	7	8		5	1	9	8	9	8	1	8	2	125.369	**29**	8	6		5	3	1		7	4		0	36.1	125.5943
DW-7	26.5	29.6		0.1	4.4	0.8		24.	60.	10.6	22	23.2		**GNT-**	47.0			0.0	1.3	0.4		30.	33.		32	37.9		**GNT-1**	45.4			0.0	1.3	0.4		18.	40.		36	36.5	
			9.97				283									8.63	2.92				148			4.10				10.9	3.44				245			5.13			
3	3	1		2	6	1		8	9	3	7	4	124.0517	**10**	2			5	2	4		5	1		3	6	125.4094	**30**	8			4	1	1		2	1		3	7	125.5948
DW-7		31.2	10.0	0.1	4.7	0.7			60.	10.6	22	22.4		**GNT-**	39.4	16.9		0.0	2.3	0.4		4.7	44.		28	32.6		**GNT-1**	37.0	20.0		0.0	2.4	0.7		10.	51.		29	30.9	
	26						291	30									5.22				410			6.90					5.85				649			8.39			
4		4	5	2	5	4			2	0	7	4	123.8187	**11**	4	5		5	1	5		2	4		7	5	125.4968	**31**	7	2		4	4	5		4	4		2	1	125.323
DW-7	22.3	34.5	11.3	0.1	5.4	0.7		39.	64.	11.6	19	20.0		**GNT-**	45.9	10.0		0.0	1.1	0.3		4.3	32.		32	37.1		**GNT-1**	41.4	14.4		0.0		0.5		5.3	43.		32	34.2	
							977										3.14				137			4.37					4.85		2		431			6.21			
5	9	3	2	4	2	8		8	0	1	5	9	123.8924	**12**	5	9		4	4	9		4	2		1	6	125.4603	**32**	5	4		4		7		8	4		0	2	125.6712
DW-7	22.6	35.8	11.1	0.1	4.2	0.6		27.	65.	12.5	20	20.1		**GNT-**		12.7		0.0	1.7	0.3			37.		29	35.3		**GNT-1**	40.1	15.5		0.0	2.1	0.6		5.5	44.		30	33.4	
							301								43.7		3.87				171	4.3		5.45					5.16				501			6.71			
6	2	3	1	2	6	0		4	5	1	1	3	123.7174	**13**		8		5	6	3			9		7	3	125.4348	**33**	5	2		4	4	3		2	8		5	1	125.5384
DW-7	21.6		11.1	0.1	4.3	0.5		27.	67.	13.5	20	19.5		**GNT-**		11.6		0.0	1.5	0.6		4.9	39.		30	35.7		**GNT-1**		10.1		0.0	1.5	0.5		25.	33.		35	37.0	
		36.9					313								44.3		3.84				193			5.08				45.6		3.15				288			4.66			
7	7		9	1	1	9		5	0	1	5	1	123.6709	**14**		6		3	7	2		7	3		1	5	125.6131	**34**		2		4	2	9		1	5		0	7	125.5489
DW-7		32.2	10.7	0.1	5.1	0.6		30.	65.	11.3	21	21.5		**GNT-**	33.6	22.9		0.0	3.6	1.0	128	7.9	99.		24	28.4		**GNT-1**	45.8			0.0	1.5	0.7		11	32.		34	37.1	
	24.4						305										6.66							9.86					9.71	3.12				407			4.29			
8		5	8	4	8	2		5	6	9	2	7	123.6665	**15**	4	5		4	5	1	7	3	9		8	7	125.261	**35**	4			4	7	1		9	6		2	9	125.6712
DW-7	26.6	29.4		0.0	4.5	0.5		27.	64.	10.7	20	23.2		**GNT-**	46.6			0.0	1.3	0.6			37.		30	37.2		**GNT-1**	44.8	10.2		0.0	1.2	0.7		29.	40.		35	36.6	
			10.4				272									9.4	3.14				152	3.8		4.28					3.86				522			4.81			
9	5	4		9	8	3		6	8	8	4	9	123.5929	**16**	7			4	5	1			6		6	3	125.7968	**36**	9	6		5	6	9		9	2		5	9	125.4155
DW-8	21.4	37.2	11.1	0.0	4.5	0.7		57.	65.	12.6	20	19.3		**GNT-**	43.9			0.0	1.6	0.4		3.7	39.		29	35.5		**GNT-1**	35.4	21.3		0.0	2.3	1.2		14	58.		29	29.6	
							844								12		4.12				207			5.37					7.14				984			9.69			
0	4	6	9	9	7	4		3	0	4	1	1	123.78	**17**	4			5	7	3		8	6		3	9	125.6651	**37**	1	6		5	4	3		1	1		4	9	125.5494
DW-8	29.0	27.3		0.1	3.9	0.5		9.2	51.		22	24.9		**GNT-**	43.9	12.3		0.0		0.4		4.2	41.		31	35.2		**GNT-1**				0.0		0.7		3.2	33.		34	37.6	
			9.09				272			9.58							3.97				342			5.42				45.9	9.04	3.24		1.1		182			4.51			
1	2	7		0	3	5		1	5		8	5	123.9405	**18**	4	9		5		6		9	7		1	8	125.6845	**38**				4		1		2	8		0	4	125.5384
DW-8	26.6	30.2		0.1	4.3	0.7		10.	57.	10.8	22	23.0		**GNT-**	44.4	11.6		0.0	1.7	0.3		4.0	54.		30	35.7		**GNT-1**	49.6			0.0	0.8	0.5		13.	25.		39		
			10.1				651			10.8						11.6	3.81				456			5.63					6.28	1.92				254			2.91			
2	5	1		1	6	3		6	8	0	6	3	123.9859	**19**	2	8		4	5	9		9	6		8	6	125.747	**39**	3			3	7	4		6	1		2	39.7	125.7885
DW-8	28.9	28.7	8.97	0.0	3.7	0.5	491	10.	50.	9.77	23	24.5	123.785	**GNT-**	43.8	13.0	3.82	0.0	1.6	0.2	179	4.4	39.	5.96	30	35.2	125.3728	**GNT-1**	36.3	21.0	6.44	0.0	2.1	1.3	440	15.	58.	9.80	29	30.3	125.7061

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8	2	5	8	5	6	0		7	8	1	5	2		**35**	6	5		6	8	5		4	5		8	2		**55**	4			4	4	0		4	1		5	4	
DW-9	17.4	38.4	13.5	0.1	6.2	0.9	110	20.	79.	14.3	18	16.7		**GNT-**	30.3	26.2		0.0	3.6	0.6		5.4	54.		24			**GNT-1**				0.0	0.9	0.6		7.8	23.		35	39.4	
9	1	6	9	2	7	3	1	2	0	7	4	6	123.8818	**36**	2	1	8.58	7	8	5	204	6	6	9.90	9	26.3	124.1403	**56**	48.8	6.43	2.23	3	1	0	196	1	8	3.76	3	8	125.359
DW-1	30.6	25.8		0.0	3.4	0.6		7.4	53.	10.6	26	25.8		**GNT-**	24.6	33.5		0.0	3.9	0.8		8.6	61.	11.4	22	21.9		**GNT-1**	47.6			0.0	1.0	0.7		8.8	23.		35	38.5	
01	8	6	8.67	9	3	1	591	3	3	4	9	9	124.2189	**37**	4	6	10	8	4	1	249	6	6	4	5	6	124.2305	**57**	1	7.9	2.61	4	9	4	215	2	7	4.34	3	1	125.39
DW-1	26.5	32.8		0.1	2.5	0.5		66	65.	13.5	28	22.8		**GNT-**	20.6	37.2	11.2	0.1	4.6	0.9			71.	12.8	20	19.0		**GNT-1**	47.6			0.0	1.0	0.6		12.	24.		33		
02	3	5	9.37	1	3	6	260	7	1	8	3	4	123.8835	**39**	1	8	4	0	8	9	405	8.3	9	9	0	2	124.1298	**58**	7	7.81	2.68	4	3	8	230	8	3	4.35	1	38.6	125.406
DW-1	28.1			0.1	2.5	0.9		12	61.	10.7	25	24.0		**GNT-**		28.5		0.1	4.5	0.7		6.4	62.	10.9	24			**GNT-1**	46.0			0.0	1.3	0.9		7.1	41.		34	37.4	
03	9	30	9.38	3	8	0	262	8	3	1	1	4	123.7606	**40**	27	6	9.99	0	4	7	446	2	4	9	0	23.9	124.3955	**59**	7	9.37	3.17	4	6	3	288	5	4	5.78	6	9	125.5239
DW-1	25.5	32.6		0.1		0.9		8.4	61.	11.6	24	22.2		**GNT-**	44.8	12.1		0.0	1.4	0.3		5.0	29.		36	35.6		**BT-1**	48.0			0.0	0.9	0.6		6.4	22.		35	38.7	
04	8	2	9.99	2	3.3	3	285	8	5	6	0	6	123.8769	**41**	9	9	3.48	7	6	5	114	6	0	4.64	1	8	124.3689		9	7.41	2.57	3	2	5	220	2	6	4.01	8	7	125.535
DW-1	29.1	28.2		0.1	3.1	0.6		11.	59.	10.4	26	24.7		**GNT-**		27.1		0.0		0.7		5.6	57.	10.2	26	25.2			48.5			0.0		0.5		7.0	19.		34	39.2	
05	4	2	8.86	4	6	5	292	6	0	2	8	8	124.0042	**42**	28.9	2	9.2	8	4	3	452	8	5	6	1	4	124.4248	**BT-2**	6	6.89	2.3	3	0.8	4	196	1	6	3.65	7	2	125.6413
DW-1		27.9		0.0	2.9	0.7		8.6	53.	10.0	27	25.3		**GNT-**	43.6	12.7		0.0	1.7	0.5		4.2	31.		33	35.2			47.2			0.0	1.0	0.7		12.	27.		33	38.1	
06	30.2	7	8.03	9	9	3	238	9	1	1	2	1	123.837	**43**	4	3	3.98	5	6	6	112	9	7	4.74	3	2	124.7691	**BT-3**	6	8.17	2.86	3	5	0	271	6	7	4.89	6	3	125.8748
DW-1	30.4			0.1	3.5	0.8			57.	10.4	30	25.6		**GNT-**	43.4			0.0	1.6	0.3		5.6	29.		35	35.0						0.0	0.6	0.4		17.	17.		32	39.9	
07	4	26.5	8.34	7	2	9	332	17	9	4	8	1	123.7883	**44**	7	13.4	3.8	8	7	2	126	9	9	5.22	9	9	124.598	**BT-4**	50.1	5.64	1.92	3	8	7	180	8	0	3.15	5	4	125.7127
DW-1	41.4			0.1	2.9	0.5		6.9	36.		34	33.1		**GNT-**	40.8	16.9		0.0	1.5	0.4			38.		33	33.1			46.0			0.0	1.2	0.8		16.	36.		33	37.4	
08	5	14.1	4.3	1	1	5	156	7	4	5.45	9	3	123.9073	**45**	6	4	4.75	5	7	7	145	5.6	0	6.51	9	2	124.5858	**BT-5**	7	9.36	3.19	3	7	9	298	8	6	5.33	4	3	125.9811
DW-1	26.2	29.6	10.4	0.1	4.7	0.6		6.3	66.	11.9	23	22.9		**GNT-**	20.8	36.3	11.6	0.1	5.1	1.0		11.	77.	12.9	20				46.1			0.0	1.2	0.8		18.	33.		32	37.4	
09	9	6	4	1	1	6	337	4	4	4	5	6	123.8957	**46**	5	6	2	1	2	9	463	1	0	2	2	19.5	124.3816	**BT-6**	9	9.4	3.17	3	4	4	297	6	9	5.43	0	8	125.9108
DW-1	41.0			0.0	1.8	0.5		4.9	36.		33	32.4		**GNT-**		18.0		0.0	2.0	0.5		5.4	37.		31	32.3			49.3			0.0	0.7	0.5		26.	17.		32	39.7	
10	4	16.1	4.58	7	8	0	181	2	7	6.97	4	6	124.6229	**47**	39.8	1	4.83	3	2	9	140	6	1	6.61	4	9	124.6451	**BT-7**	9	5.74	1.96	3	3	3	194	2	3	3.08	3	8	126.1399
DW-1		13.8		0.0		0.3		5.1	30.		35			**GNT-**	45.5	12.0		0.0	0.9	0.8		36.	30.		37	36.4			47.9			0.0		0.8			20.		33	38.9	
11	43.7	2	3.65	5	1.5	7	149	1	5	5.50	2	34.1	124.3916	**48**	4	4	2.92	3	8	9	194	4	5	4.93	8	3	124.3949	**BT-8**	7	7.41	2.56	3	0.9	1	247	20	8	3.91	4	7	126.0408
DW-1	34.5	23.4		0.1	2.4	0.5		6.3	45.		29	27.9		**GNT-**	45.9	12.0		0.0	0.7	0.6		77.	28.		31	36.4			48.3			0.0	0.9	0.8		8.2	21.		36		
12	8	7	6.57	1	2	1	512		1	8.23	0	2	124.2704	**49**	5	8	2.92	4	8	9	127	6	7	5.05	4	8	124.9118	**BT-9**	8	7.51	2.37	5	2	2	198	8	7	3.87	6	39.1	125.2388
DW-1	29.8	26.8		0.0	3.4	0.5		5.8	56.	10.1	23	25.4		**GNT-**	42.1	16.3		0.0	1.2	0.5		3.7	34.		29	34.2															
13	5	7	8.84	8	4	0	256	5	1	2	8	9	124.0855	**50**	6	7	3.62	3	3	0	224	8	2	6.25	0	3	125.0369														
DW-1	29.2	28.7	8.68	0.0	3.0	0.5	242	6.5	57.	11.2	24	24.8	124.2959	**GNT-**	45.0	12.4	2.89	0.0	1.0	0.5	129	3.6	28.	5.13	31	36.4	125.0978														

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Table S3. Direction statistics of vertical argillaceus bands in the Xiangxi area and Anhui area (°)

Xiangxi area (each data is the average value of a geosite)																			
No.	Direction	No.	Direction	No.	Direction	No.	Direction	No.	Direction	No.	Direction	No.	Direction	No.	Direction	No.	Direction	No.	Direction
1	40°	13	47	25	50	37	47	49	52	61	56	73	50	85	46	97	49	109	48
2	42	14	38	26	50	38	46	50	38	62	39	74	49	86	42	98	46	110	50
3	51	15	40	27	42	39	52	51	42	63	50	75	44	87	47	99	39	111	45
4	41	16	47	28	54	40	44	52	54	64	43	76	42	88	45	100	47	112	47
5	45	17	52	29	56	41	47	53	45	65	45	77	46	89	49	101	46	113	53
6	38	18	44	30	46	42	46	54	49	66	49	78	39	90	43	102	42	114	45
7	43	19	48	31	40	43	55	55	57	67	43	79	50	91	48	103	46	115	56
8	46	20	45	32	45	44	46	56	40	68	39	80	47	92	45	104	42	116	48
9	41	21	49	33	55	45	49	57	43	69	57	81	47	93	47	105	50	117	54
10	43	22	51	34	49	46	45	58	50	70	51	82	45	94	42	106	43	118	42
11	49	23	48	35	41	47	46	59	57	71	41	83	46	95	48	107	49	119	52
12	43	24	49	36	43	48	48	60	46	72	46	84	48	96	54	10	52	12	50

																8		0	
Anhui area (the values here are for individual direction, not the average of geosites)																			
200	200	201	202	202	202	203	203	203	204	204	205	205	206	206	208	208	209		
209	210	210	210	210	210	210	211	211	211	212	212	212	212	212	212	213	213		
213	213	213	213	213	214	214	214	214	214	214	214	214	215	215	215	215	216		
216	216	216	216	216	216	216	216	217	217	217	217	217	217	217	218	218	218		
218	218	218	218	218	218	219	219	219	219	219	219	219	220	220	220	220	220		
220	220	221	221	221	221	221	221	221	221	222	222	222	222	222	222	222	223		
223	223	223	223	223	223	223	223	224	224	224	224	224	224	224	224	225	225		
225	226	226	226	226	226	226	226	226	227	227	227	227	227	227	228	228	228		
228	228	228	228	229	229	229	229	229	229	229	229	229	229	229	229	229	229		
229	229	230	230	230	230	230	230	231	231	231	231	231	231	231	232	232	232		
232	232	233	233	233	233	233	234	234	235	235	235	236	236	237	238	238	238		
238	238	239	239	239	240	241	241	242	243	246	246	247	249	250					

Table S4. Previous Interpretations of the Genesis of "nodule-like" Structures

Genesis	Citing Literature; Region	Description of Features in Literature
Dominant differential compaction, with other factors such as original formation, exposure, slumping, and diagenesis	Guo and Liang (1993); Western Zhejiang	Interbedded layers of argillaceous and calcareous strata undergo lateral flow during compaction, resulting in flattened nodule formations
Periodic bottom current action	Zhang et al. (2009); Western Zhejiang	Repeated bottom current dissolution of deposited carbonates, forming the protolith of nodule limestone, i.e., interlayers of carbonate rocks and calcareous mudstone
Differential compaction—pressure dissolution	Yang et al. (2017); Songzi, Hubei	In the late stage of diagenesis, under the pressure of overlying strata, argillaceous limestone with poor cementation and simple structure is subject to differential dissolution, with calcium dissolving and migrating outward, while argillaceous material remains in place due to its low solubility

Table S5 Previous Interpretations of the Genesis of "cracked" Structures (modified after Liao et al., 2017; Zhou et al., 2022)

Genesis	Citing Literature	Description of Features in Literature	Controversy
Exposure desiccation	Wu et al.,（1989） Li et al.,（2012）	Bird's eye and mud crack structures; chemical characteristics of water	Accompanying marine fossils exist; palaeosalinity; strata are generally in conformable contact
Subaqueous shrinkage	Chen and Qiu,（1986） Rong and Chen,（1987） Fang et al.,（1994） Wang et al.,（2012）	Lithology and paleontological assemblages; paleo-geographic environment (transgression to regression); thin-section analysis indicates a marine depositional environment; dehydration and shrinkage of argillaceous calcareous sediments	Uncertainty about the colloidal state of calcium carbonate particles; lack of physical conditions for the formation of subaqueous shrinkage cracks; unbroken biological shell bodies
Submarine hardground contraction	Wang（1996）	extremely slow sedimentation rates and deep sedimentary environments	Lacking typical hardground features such as hardground cavities, mineralization, and sedimentary hiatuses. The Pagoda Formation does not possess the important characteristics of extremely thin beds, rich in organic matter, etc.
Differential load	Zhou and Xue（2000）	Deposits of different densities form load casts, with more fluid-rich, low-density layers of water and clay moving upward into higher-density layers, forming flame structures and water escape structures.	Numerous scholars have not observed this structural phenomenon in the field

Biological trace facies	Xu et al.,（2001）	The basin migration driving mechanism created the ecological space and special phase required for the life of Late Ordovician nautiloids.	With a wide distribution range, the migration traces of organisms are too consistent.
Diagenetic-tectonic action	Wang（1995） Huang et al.,（2019） Zhou et al.,（2022） Chen et al.,（2023）	Active tectonic movements and pressure dissolution during the Ordovician; some scholars suggest that later Indosinian-Yanshanian movements participated in the transformation.	In field observations, the biological fossils are complete, and the fracture bands are straight and directionality. This viewpoint has a relatively high degree of acceptance.
Diagenetic structures in a special period	Shen (1989) Zhan et al．（2016） Liao et al.,（2017）	Biological debris components and paleoclimate, paleoenvironment, etc.; geochemical analysis (including carbon and oxygen isotopes, major and trace elements, rare earth elements, etc.)	Cannot well explain a large number of oriented fractures and argillaceous bands.

References

1. GB/T 14506.28-2010. Methods for chemical analysis of silicate rocks - Part 28: Determination of 16 major and minor elements content. Ministry of Natural Resources, China, 2011-02-01.
2. GB/T 14506.30-2010. Methods for chemical analysis of silicate rocks - Part 30: Determination of 44 elements. Ministry of Natural Resources, China, 2011-02-01.
3. Chen, X.Q.; Zhang, L.F. Carbon sequestration, transport, transfer, and degassing: Insights into the deep carbon cycle. Earth Sci. Front. **2023**, 30, 313–339.
4. Chen, X.; Qiu, J.Y. The Paleoenvironmental Evolution of the Ordovician in Yichang. J. Stratigr. **1986**, 10, 1–15.
5. Fang, S.X.; Hou, F.H.; Lan, G.; Deng, M. Genesis of 'Horseheely Crack' Texture And Its Hydrocarbon Potential In Middle Ordevician Baota Limestones In Sichuan And Guizhou. Mar. Orig. Pet. Geol. **1994**, 1, 36–40.
6. Guo, F.S.; Liang, D.X. On The Origin of Nodular Limestone in Yanwashan Formation in Jiangshan, Zhejiang. Mineral. Petrol. **1993**, 13, 74–80.
7. Huang, L.Q.; Liu, W.; Bai, D.Y.; Li, Z.H.; Liang, E.Y.; Chen, Z.B. Characteristics, Petrogenesis and Resource Significance of the Limestone with Polygonal Reticulate Structure of Pagoda Formation, in Northwestern Hunan Province. Earth Sci. **2019**, 44, 399–414.
8. Keith, M.L.; Weber, J.N. Carbon and oxygen isotopic composition of selected limestones and fossils. Geochim. Cosmochim. Acta **1964**, 28, 1787–1816.
9. Li, X.N.; Liao, Y.P.; Deng, T.; Li, G.B. Insights into the origin of turtle crack limestone in Wansheng District, Chongqing. West-China Explor. Eng. **2012**, 24, 113–117.
10. Liao, J.J.; Ma, S.H.; Liao, G.M.; Xiao, X.W.; Lin, D.; He, W.L.; Liao, J.H. Research of the Origin of Network Structure in the Ordovician Pagoda Limestone: Advances and New Discovery. Acta Sedimentol. Sin. **2017**, 35, 241–252.
11. Rong, J.Y.; Chen, X. Faunal differentiation, biofacies and lithofacies pattern of late Ordovician (Ashgillian) in South China. Acta Palaeontol. Sin. **1987**, 26, 507–535.
12. Shen, J.W. New Observations of the Origin of Baota Limestone in Guizhou and Its Adjacent Regions. J. Stratigr. **1989**, 6, 35–38.

13. Wang, A.D.; Zhou, Y.Q.; Zhong, Y.L.; Duan, J.; Wang, Z.Y.; Zhang, Z.K. Causes of Reticular Cracks in Ordovician Baota Formation Limestone in Southern Shaanxi. Earth Sci. Front. **2012**, 37, 843–850.
14. Wang, Y. Middle Ordovician cracked limestones of polygonal structure in the upper Yangtze River area, south China's new interpretation of their origin. Acta Geol. Sin. **1995**, 30, 268–274.
15. Wang, Z.Z. Baota Formation-a middle Ordovician condensed section. J. Stratigr. **1996**, 16, 18–21.
16. Wu, J.W.; Xia, S.F. Notes on the origin of the "Polygonal marking" limestones. Acta Sedimentol. Sin. **1989**, 25, 136–141.
17. Wu, L.J.; Wang, P.J.; Ye, Q.Z.; Huang, C.; Quan, X.Q.; Wei, H.X.; Li, F.Y. Characteristics of carbon and oxygen isotopic compositions and the palaeoenvironmental significance of Ordovician red carbonate rocks in Xiangxi, Hunan. Acta Geol. Sin. **2023**, 97, 1245–1261.
18. Xu, Z.J.; Lan, Y.Z.; Cheng, R.H.; Li, S.L. Carbonate geochemical record of sea-level change of Lunshan Formation in Lower Ordovician in Jurong area. J. Jilin Univ. (Earth Sci. Ed.) **2017**, 47, 1458–1470.
19. Xu, X.S.; Wan, F.; Yin, F.G.; Chen, M. Environment facies, ecological facies and diagenetic facies of Baota Formation, of late Ordovician. Mineral. Petrol. **2001**, 21, 64–68.
20. Yang, Z.W.; Xiao, C.T.; Ran, L.Y.; Ye, F.; Xu, D. Research on the genesis of the oncoid limestone in the Dayuan Formation at Liujia Scene, Songzi, Hubei. China Pet. Chem. Stand. Qual. **2017**, 37, 87–88.
21. Zhan, R.B.; Jin, J.S.; Liu, J.B.; Corcoran, P.; Luan, X.C.; Wei, X. Meganodular limestone of the Pagoda Formation: A time-specific carbonate facies in the Upper Ordovician of South China. Palaeogeogr. Palaeoclimatol. Palaeoecol. **2016**, 448, 349–362.
22. Zhang, X.L. Relationship between carbon and oxygen stable isotope in carbonate rocks and paleosalinity and paleotemperature of seawater. Acta Sedimentol. Sin. **1985**, 3, 17–30.
23. Zhang, X.; Lin, C.M.; Ling, H.F.; Jiang, S.Y.; Li, Y.L.; Gao, L.K.; Yao, Y.L.; Liu, X. Nodular limestone and its genesis from the Ordovician Yanwashan Formation in western Zhejiang Province. J. Palaeogeogr. **2009**, 11, 481–490.
24. Zhou, C.M.; Xue, Y.S. On Polygonal Reticulate Structure of the Ordovician Pagoda Formation of the Western Hunan Hubei Area. Earth Sci. Front. **2000**, 24, 307–309.
25. Zhou, G.; Qian, H.B.; Long, H.Y.; Zeng, Y.X.; Yan, W.; Zhu, H.; He, Y.; Wang, W.Z.; Huang, M.X.; Chen, X.; et al. Structural differentiation and development model of cracked limestone of Pagoda Formation in northern margin of Upper Yangtze Region. Nat. Gas Explor. Dev. **2022**, 45, 11–23.